Turbulence Assessment and Monitoring System (TAMS)

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The "Costs" of Turbulence

- Upsets
- Injuries (especially flight attendants)
- Increased operating costs
- Lower revenues

Problems with Current Turbulence Reporting System

- Forecasts are not precise
- Definitions used by pilots for turbulence reporting are not precise
- Reports are not aircraft specific
- Occupant reaction is subjective

Goals

- Determine standardized, objective way to measure turbulence
- Design a pilot-centered system
- Consider the business case

Major Participants

- Search Technology, Inc.
- NASA (Technical Monitor: Bob Stuever)
- Delta Air Lines
- Aerotech Research
- National Center for Atmospheric Research

What Pilots Want To Know!

(Based on survey of 270+ major, regional, and foreign commercial airline jet pilots)

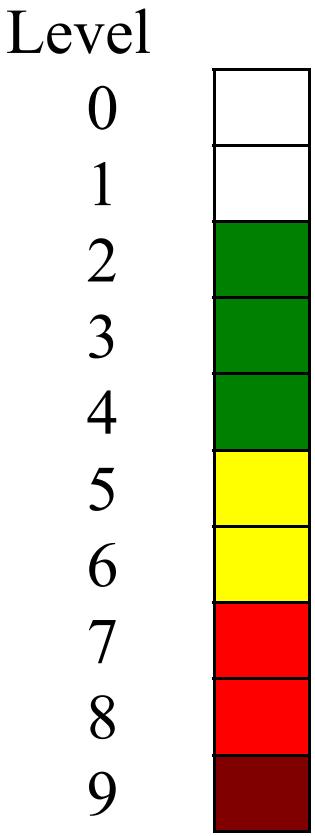
Current turbulence level

Peak turbulence over the last 5 minutes

- Level
- Frequency

Occasional - O	0 - 1/3 of the time
Intermittent - I	1/3 - 2/3 of the time
Continuous - C	> 2/3 of the time

Turbulence Metric



Tailor the meaning for each aircraft type!

Smooth	
Light	
Moderate	
Severe	
Extreme	

Example

2/O4

Current turbulence is 2

Peak level over the past 5 minutes is 4

Peak frequency is occasional

< 1/3 of the time, the level has been at 4

Short and Long Term Strategy

- Ownship display
  - Mostly software
- Verbal PIREPs with TAMS values + ...
  - Mostly software
- Traffic Turbulence Display (40 miles) + ...
  - Software plus communication capability
- Traffic Turbulence Display (120 miles) + ...
  - Software plus improved communication infrastructure

Simulator Experiment

Level D full motion simulator

16 commercial airline pilots

5 experimental treatments (baseline plus 4 "strategies"

8 scenarios

8 Scenarios

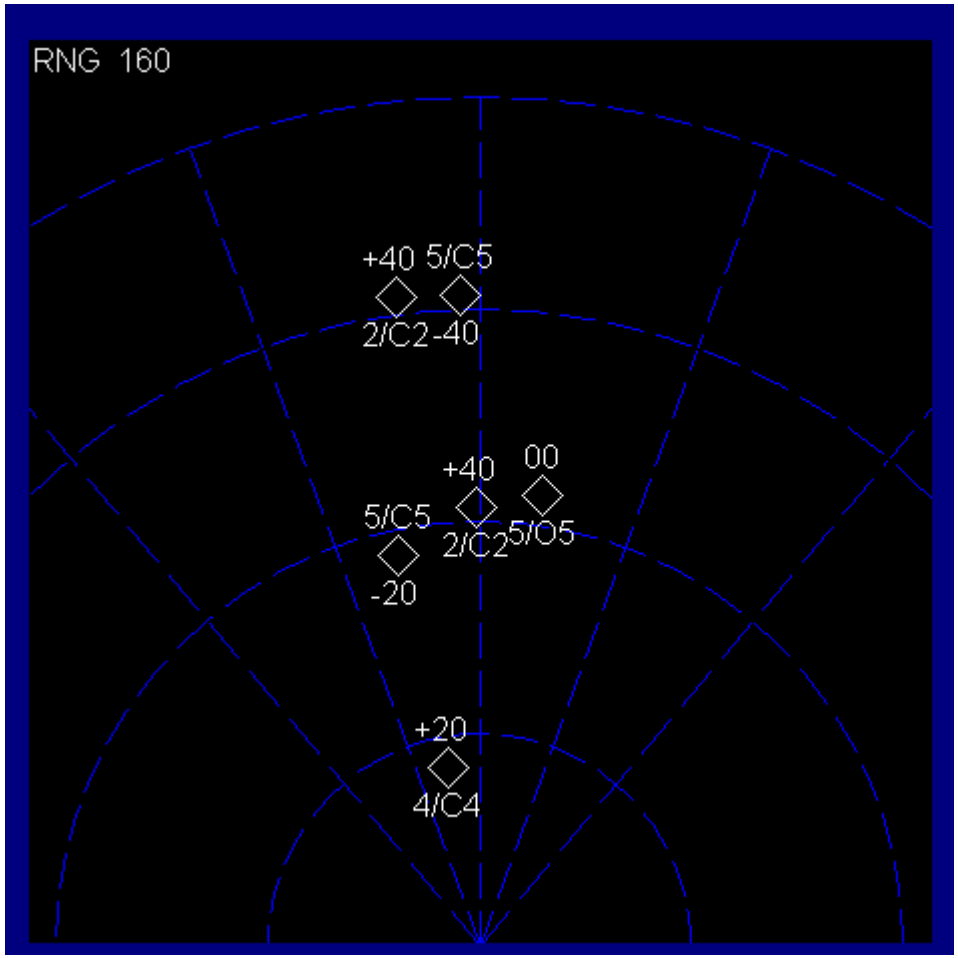
Pilot reports:

- Same as participant aircraft
- Over/under-reporting

4 atmospheric conditions:

- All light
- Prepare cabin
- Smooth above
- Smooth below

Smooth Above Scenario Example



Dependent Variables

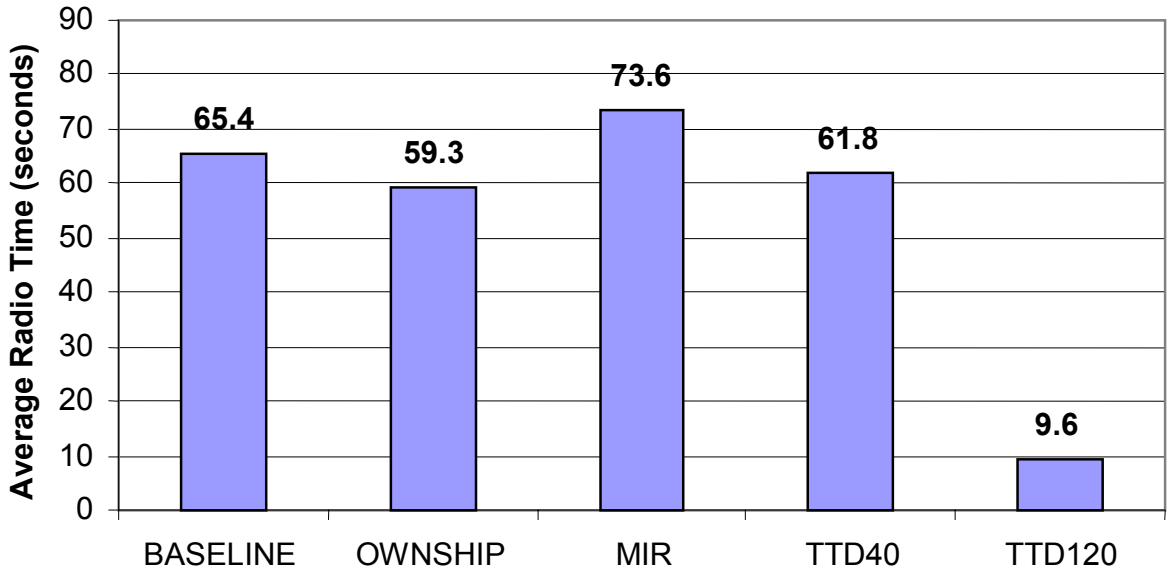
Workload (ride report communications)

Decision times

Decision quality

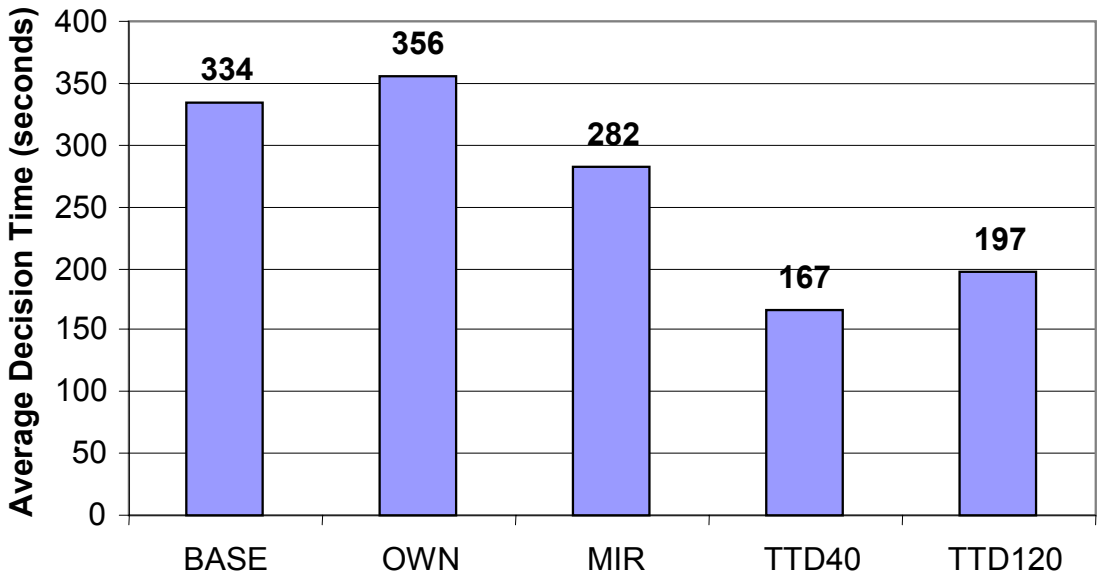
- Flight attendant/passenger safety
- Passenger comfort
- Flight planning decisions with respect to economy

Average Radio Communication Time



Time to obtain pilot reports reduced significantly with 120-mile Traffic Turbulence Display

Time to Make Decision After Turbulence Onset



Reduction in decision times in the Traffic Turbulence Display-aided conditions

Quality of decisions

Quality Considerations	TAMS numeric convention vs. LMS	Transmission on Display vs. Radio	TAMS Display vs. TAMS Radio
Passenger Safety	80/80 vs. 61/62	48/48 vs. 93/94	48/48 vs. 32/32
Flight Attendant Safety	**87/88 vs. 56/62**	55/56 vs. 88/94	55/56 vs. 32/32
Passenger Comfort	**88/88 vs. 58/62**	56/56 vs. 90/94	56/56 vs. 32/32
Economy	81/88 vs. 53/62	**55/56 vs. 79/94**	**55/56 vs. 26/32**

TAMS-aided turbulence reporting provided significantly better passenger comfort and flight attendant safety than light/moderate/severe (LMS) convention

Traffic Turbulence Display enhanced flight plan decision making with respect to economy

Anticipated Benefits from TAMS

- Improved operational safety through improving pilot situation awareness of turbulence location and severity
- Improved customer satisfaction of flight experience by reducing exposure to turbulence
- Improving operational efficiencies and profitability by allowing pilots to optimize flight path decisions in areas of turbulence